ORIGINAL RESEARCH

Study of the Immunization Status and Reasons for Incomplete Vaccination of Children Attending an Urban Hospital

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Received on: 05 September 2020; *Accepted on:* 28 September 2020; *Published on:* 31 August 2022

Abstract

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Introduction: Immunization is one of the main health interventions to prevent childhood morbidity and mortality.

Need of the study: We noticed that the vaccination status of the children admitted in our hospital differed markedly from what was recommended by the Indian Academy of Pediatrics (IAP), despite most of the families living in the city and having access to health care.

Objective: The study was conducted in order to assess the magnitude of the problem and the factors affecting the immunization status of the children.

Materials and methods: Children between the age of 6 weeks to 18 years attending an urban hospital were included in study, which was conducted for a period of 9 months from September 1, 2017 to May 31, 2018. The IAP 2016 Immunization Guidelines were taken as the standard. Based on these guidelines, children were categorized as completely immunized, partially immunized, or unimmunized for their age depending on the level of immunization they had received.

Result: A total of 378 children were included in the study. We found that 32.3% (122) children were completely immunized and 67.7% (256) of children were partially immunized. The most common reasons for partial/nonvaccination included (a) unawareness of the need for vaccination, followed by (b) financial constraints, (c) child being ill, and (d) postponing vaccination to another time for no apparent reason. Completion of schedule of vaccines that requires multiple doses (e.g., OPV and DPT or Pentavalent) remains a major challenge toward achieving higher full immunization coverage.

Keywords: Immunization status, Partial immunized, Urban.

Pediatric Infectious Disease (2022): 10.5005/jp-journals-10081-1280

Introduction

The World Health Organization (WHO) initiated the Expanded Program of Immunization (EPI) in May 1974 with the objective to vaccinate children throughout the world, in order to save children from life-threatening, disabling, "vaccine-preventable diseases" (VPDs). Ten years later, in 1984 the WHO established a standard vaccination schedule for the original EPI vaccines BCG, DPT, oral polio, and measles. Increased knowledge of the immunologic factors of diseases led to new vaccines being developed and added to the EPI's list of recommended vaccines, for example, hep B, yellow fever (in countries endemic for the disease), and HiB conjugate vaccine in countries with high burden of disease.[1] In 1985, the Universal Immunization Program (UIP) was started in India with the aim of achieving at least 85% coverage of primary immunization of infants, i.e., three doses of DPT and OPV and one dose of BCG and measles by the year 1990.[2] In 1999, the Global Alliance for Vaccines and Immunization (GAVI) was created with the sole purpose of improving child health in the poorest countries by extending the reach of EPI. The GAVI brought together a grand coalition, including the UN agencies and institutions (WHO, UNICEF, the World Bank), public health institutes, donor and implementing countries, the Bill and Melinda Gates foundation and the Rockerfeller Foundation, the vaccine industry, NGOs, and many others. The creation of GAVI has helped to renew interest and maintain the importance of immunization in the battle against the world's large burden of infectious diseases.[3]

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How to cite this article: Sabahath F, Lewis P. Study of the Immunization Status and Reasons for Incomplete Vaccination of Children Attending an Urban Hospital. Pediatr Inf Dis 2022;4(3):92–100.

Source of support: Nil

Conflict of interest: None

Before the initiation of EPI, the child vaccination coverage for TB, DPT, and measles was estimated to be less than 5%. Now, not only has coverage increased to 75%,[4] it has been expanded to include vaccination for hep B, HIB, rubella, tetanus, and yellow fever. The impact of increased vaccination is clear from the decreased incidence of many childhood infectious diseases.

For example, deaths due to measles decreased by 60% worldwide between 1999 and 2005, and polio, although missing the goal of eradication by 2005, has decreased significantly as there has been fewer than 2,000 cases in 2006.[4]

Immunization is one of the most cost-effective interventions to prevent the suffering that comes from avoidable sickness, disability, and death.

The benefits of immunization are not only restricted to improvements in health and life expectancy but also have social and economic impact at both community and national levels.[5]

Though some improvements have taken place in the past few years, the country still accounts for the largest number of children who are not immunized (7.4 million).[5]

The Ministry of Health and Family Welfare, Government of India, New Delhi, and UNICEF conducted an evaluation of immunization in the year 2001–2002 and estimated a decrease in immunization coverage from 68% during 1996–1997 to 38% in 1999–2000. The evaluation showed that the coverage level for fully vaccinated children was over 80% in Tamil Nadu, Kerala, Maharashtra, and Karnataka.

It was in the range of 60–80% in West Bengal, Madhya Pradesh, Punjab, Delhi, and Andhra Pradesh. In Uttar Pradesh, Jharkhand, Rajasthan, and Bihar, less than 30% of infants were fully vaccinated. The most recent data on vaccine-preventable mortality in India are from a 2008 study,[6] which estimated that of the 826,000 deaths in children aged 1–59 months, almost three-quarters or 604,000 deaths were due to VPDs including diarrhea, pertussis, measles, meningitis, and pneumonia. Collectively, the burden of these diseases highlights the significant human cost of the poor vaccination coverage among infants and children in India.

Developments in vaccines and immunization provide us with tremendous opportunities to impact the health of our populations, particularly the health of poor and marginalized communities, who carry a disproportionate burden of disease. Now is the time to seize the moment and commit to achieving immunization's full potential. Immunization is and should be recognized as a core component of the human right to health, and a personal and collective community responsibility. To be successful in the future, we must tackle the technical, logistical, political, and social obstacles that hamper progress in reaching every child with available vaccines.[7]

Materials and Methods

The study was conducted over a period of 9 months, from September 1, 2017 to May 31, 2018, in children attending an urban hospital in Bengaluru. Children brought to the hospital were from various religions, ethnicities, and socioeconomic strata of society. Children belonging to rural and urban areas were included in the study. A total of 378 children were enrolled in the study. The ages ranged from 6 weeks to 18 years of age. Before entering the child in the study, a written consent was obtained from the parents, after explaining the purpose of the study. Data were collected through a preformed questionnaire that included parameters such as age and sex of the child and age of the parents. Religion and mother tongue were used to assess ethnicity.

The Modified Kuppuswamy Classification based on education, occupation, and income of the parents was used to assess the socioeconomic status. The type of family—nuclear, joint, or single parent—and marital status of parents were recorded. In children aged less than 18 months, information was obtained about maternal antenatal visits, and a mother was considered to be booked if she had had at least three antenatal visits during her pregnancy. Information was also obtained regarding the parity of the mother, the place of delivery (hospital or home), and the birth order of the child. Details of the child's immunization were gathered by checking the child's immunization card. If the immunization card was unavailable, the assessment of the immunization status depended on mother's recall. The information about the source from where the child received vaccine was also recorded. The immunization status of the child was determined by comparing the immunization achieved by the child to the recommendations for immunization made by the Indian Academy of Pediatrics (IAP) schedule 2016.[8]

All efforts were made to interview mothers vs the fathers, as they were the primary caregivers at home. In case, the parents were not available at the time of first approach by the investigator, repeat visits were made later. Children were classified as completely immunized if they had received all the recommended vaccines for their age, not immunized if they had received none of the vaccines, and partially immunized if they had received some of the recommended vaccinations.

The immunization status of the children was also compared to the recommendations made by the National immunization Programme 2017.[9]

The reasons for incomplete/partial immunization were documented. Regardless of the child's vaccination status, at the end of the questionnaire, the mother was explained about the importance of immunization. She was counseled to complete the immunization as soon as possible where vaccination was pending, and reminded about the next vaccination if child was completely immunized for age. The data were fed into the Excel sheet and analyzed. All the analyses were carried over using SPSS version 18.0.

Result

Total 378 children were included in the study. Three of these children were orphans. Total 104 (27.5%) were infants, 106 (28%) were between 1 and 3 years of age, 51 (13.5%) were between 3 and 5 years of age, 95 (25%) were aged 5–12 years, and 22 (5.8%) were teenagers at the time of the study (Table 1).

We found that as the child got older, the number of vaccinations the child received steadily decreased, with marked decrease seen after 3.5 months of age (Table 2). At 1 year of age, only 107 (39%) of eligible children were fully immunized for age, and at 18 months, 78 (35%) of eligible children had received all the recommended vaccinations. By 5 years, 32 (22.9%) of eligible children had been fully vaccinated, and by 10–12 years, only 4 (9.5%) children were taking the recommended vaccinations.

Total 166 (43.9%) children were females and 212 (56.1%) were males. Majority of the children (95.8%) were from the urban areas and 16 (4.2%) were from the rural area. This explains the significant association we found between place of origin and complete immunization status for age ($p = 0.014$).

Most of the children were Hindus (66.4%), 67 (17.7%) were Muslims, 58 (15.3%) were Christians, and 2 (0.5%) of the children's religious affiliation was undetermined. Total 125 (33.1%) of the child–parent pairs spoke Tamil, 99 (26%) spoke Kannada, 65 (17.2%) spoke Urdu, 56 (14.8%) spoke Telegu, 14 (3.7%) understood Hindi, and 17 (4.5%) spoke other Indian languages.

Total 28 (7.7%) of the families came from the upper class, 150 (41.4%) were from upper-middle class, 127 (35%) families were from the lower-middle class, and 57 (15.2%) families belonged to the lower-class category as per the modified Kuppuswamy socioeconomic assessment scale. Children from 57.1% of upperclass families, 55.3% of the upper middle class, and 17 (13%) of the lower middle class families were completely vaccinated for age. Only 3 (5.2%) of the children from families in the lower-class category were completely immunized ($p \leq 0.001$).

Total 220 (58.2%) children came from nuclear families, 148 (39.1%) children were from joint families, 8 (2.1%) children came from single-parent families, and 3 children were orphans.

Table 1: Characteristics of the study population

Characteristics	*Total 378*	*%*	*Complete immunization*	*Partial immunization*	*p-value*
Ages					
Infants	104	27.5	59	45	
1–3 years	106	28	42	64	
3–5 years	51	13.5	14	37	
5–12 years	95	25.1	7	88	
Teenagers	22	5.8	0	22	
Gender					
Males	212	56.1	72	140	0.428
Females	166	43.9	50	116	
Area of origin					
Urban	362	95.8	122	240	0.014
Rural	16	4.2	0	16	
Ethnicity: Religion					
Hindu	251	66.4	80	171	0.928
Muslim	67	17.7	23	44	
Christian	58	15.3	19	39	
Others	2	0.5			
Ethnicity: Language					
Tamil	125	33.1	45	80	0.58
Kannada	99	26.2	27	72	
Urdu	65	17.2	21	44	
Telegu	56	14.8	17	39	
Hindi	14	3.7	4	10	
Others	17	4.5	8	19	
Socioeconomic state					
Upper	28	7.4	16	12	<0.001
Upper middle	150	39.7	83	67	
Lower middle	127	33.6	17	110	
Upper lower	46	12.2	3	43	
Lower	11	2.9	0	11	
Type of family					
Nuclear	220	58.2	64	156	0.172
Joint	148	39.1	56	92	
Single parent	8	2.1	2	6	
Orphan	3	0.8			
Marital status of parents					
Married	361	95.5	118	243	0.325
Separated	7	1.8	2	5	
Widowed	7	1.8	1	6	
Orphaned child	3	0.8	1	2	
Maternal age					
≤20 years	7	1.8	2	5	0.002
20–35 years	316	83.6	114	202	
≥35 years	52	13.7	6	46	

Contd…

Contd…

Characteristics	*Total 378*	*%*	*Complete immunization*	*Partial immunization*	*p-value*
Antenatal care mother in <18 months					
Booked	140	37	76	64	0.902
Not applicable	238	63	46	192	
Parity					
1	204	53.9	91	113	<0.001
2	131	34.7	27	104	
3	30	7.9	4	26	
4	10	2.6	0	10	
Orphans	3				
No. of living children					
1	198	52.4	89	109	<0.001
2	138	36.5	29	109	
3	30	7.9	4	26	
4	8	2.1	0	8	
Place of delivery					
Hospital	374	98.9	122	252	0.326
Home	2	0.5	0	2	
Orphan x2	Not Known				
Birth order					
1	271	71.6	92	179	0.607
2	87	23	25	62	
≥3	17	4.5	4	13	
Vaccine source					
Government	184	48.7			
Private	184	48.7			
Mixed	10	2.6			
Availability of vaccine card					
Available	208	55			
Not available	170	45			

Total 7 (1.8%) of the mothers were less than 20 years of age, 316 (83.6%) of the mothers were between 20 and 35 years of age, and 52 (13.7%) mothers were aged more than 35 years. Six (52%) children born to mothers aged more than 35 years had less immunization coverage compared to two (28.5%) children born to mothers less than 20 years of age and 114 (36%) children born to mothers between 20 and 35 years of age ($p = 0.002$).

Total 204 (53.9%) of mothers were primiparous and 165 (43.6%) mothers were multiparous. Total 91 (44.6%) children of primiparous mothers were completely immunized compared to 31 (18.1%) children born to multiparous mothers suggesting immunization rates decreased as maternal parity increased ($p \leq 0.001$).

Total 140 (37%) children aged less than 18 months of age were present in the study. All of their mothers had received regular antenatal care and counseling during pregnancy. Total 198 (52.4%) of the mothers had a single child at home, 138 (36.5%) mothers had two children, and 38 (10%) mothers had three or more living children. Completion of immunization rates were higher in 89 (44.9%) families with a single child at home compared to 33 (18.6%) families with two or more living children ($p \leq 0.001$).

Only 2 (0.5%) children were home delivered. The rest of the mothers delivered their offspring in hospitals. The place of delivery of two of the orphans could not be determined. Total 269 (71.6%) children were first born, 87 (23%) children were birth order 2, and 17 (4.5%) were birth order ≥3. Total 184 (48.7%) children were vaccinated at the government hospitals, an equal number got vaccinated from a nongovernmental source, and 10 (2.6%) children received vaccination from both governmental and nongovernmental sources.

Verification of immunization by the immunization card was possible in 208 (55%) children. In 170 (45%) children, that vaccination status was based on parental recall only, as the card was unavailable.

We did not find any significant association between immunization status and gender, religion, language, type of family, marital status of parents, quality of maternal antenatal care, place of delivery, birth order of the child, or source of vaccine.

Immunization rates were highest at birth (95.5%) and subsequently declined over time (Tables 2 and 3A). Of the 378 children in the study, 1 child received no immunization at birth, and 16 (4.2%) children received partial immunization. Total 76.4%

Table 2: Distribution of the number of study subjects and their immunization coverage (*N* = 378)

Immunization coverage	*Completely immunized*	*Partially immunized*	*Not immunized*
At birth (*n* = 378)	361 (95.5)	16 (4.2)	1 (0.3)
At 6 weeks (*n* = 378)	168 (44.4)	208 (55.0)	2 (0.5)
At 10 weeks (*n* = 358)	153 (42.7)	202 (56.4)	3 (0.8)
At 14 weeks (*n* = 354)	152 (42.9)	199 (56.2)	3 (0.8)
At 6 months (*n* = 337)	140 (41.5%)	15 (4.5%)	182 (54%)
At 9 months (*n* = 309)	113 (36.6)	189 (61.2)	7 (2.3)
At 9–12 months (*n* = 285)	118 (41.4)	–	167 (58.6)
At 12 months (*n* = 273)	107 (39.2)	–	166 (60.8)
At 15 months (*n* = 254)	103 (40.6)	138 (54.3)	13 (5.1)
At 16–18 months (*n* = 239)	91 (38.1)	137 (57.3)	11 (4.6)
At 18 months (*n* = 223)	78 (35.0)	–	145(65)
At 2 years (*n* = 211)	81 (38.4)	–	130(61.6)
At 4–6 years (*n* = 140)	32 (22.9)	59 (42.1)	49 (35.0)
At 10–12 years (*n* = 42)	4 (9.5)	18 (42.9)	20 (47.6)

Table 3A: Distribution of study subjects according to the partial/noncoverage of immunization (part A)

	Age						
Immunization	*Birth*	*6 weeks*	*10 weeks*	*14 weeks*	*6 months*	*9 months*	*9–12 months*
BCG	2 (11.7)						
OPV	1 (5.88)				3 (1.5)		
HBV	13 (76.4)	3 (1.42)	3 (1.5)	4 (2.0)	13 (6.5)		
OPV and HBV					181 (91.8)		
DTwP		2 (1.0)	2 (1.0)	3 (1.5)			
Hib		2 (1.0)	2 (1.0)	3 (1.5)			
Rotavirus		209 (99.5)	203 (99)	201 (99.5)			
PCV		205 (97.6)	201 (98)	198 (98.0)			
MMR						195 (99.4)	
Measles						5 (2.5)	
Typhoid							0
Sum total of partial immunized	16 (4.2)	208 (55.0)	202 (56.4)	199 (56.2)	15 (4.4)	189 (61.1)	0 (NA)
Sum total of partial and nonimmunized	17 (4.5)	210 (55.5)	205 (57.2)	202 (57.0)	197 (58.4)	196 (63.4)	167 (58.5)

of these partially immunized children did not receive HepB vaccine and 11.7% did not get BCG vaccine at birth.

There was a sharp decline in complete immunization rates from birth (95.5%) to 6 weeks of age (44.4%). Between 6 and 14 weeks of age, the overall complete immunization rates were 98–99% as per the National immunization Program (NIP) and 43–44% as per the IAP (2016) schedule. Of the 55–56% children aged 6–14 weeks, who received partial immunization, 205 (98%) did not receive the pneumococcal (PCV) and rotavirus vaccines.

At 6 months of age, 182 (54%) of the eligible children did not receive the polio drops or hep B vaccines.

By 9 months of age, 97.7% of children received the recommended vaccines as per the NIP but only 113 (36%) of eligible children received the MMR/OPV vaccines as per the IAP (2016) schedule. Total 189 (61.2%) of eligible children in the study had received the measles vaccine only at 9 months of age.

Only 118 (41.4%) of eligible children received the typhoid/hepatitis A vaccination by 12 months of age (Tables 2 and 3A). By 15 months, 241 (94.8%) children were vaccinated according to the NIP with the MR vaccine, but only 40.6% of eligible children received both MMR and varicella vaccines as per the IAP (2016) recommendations.

By 18 months, 78 (35%) of the eligible children had received DPT/HiB/OPV/PCV booster vaccines and 145 (65%) of the eligible children did not take these vaccines.

Only 81 (38.4%) of eligible children were vaccinated with the second dose of typhoid and hepatitis A vaccines by 2 years of age.

Thirty-two (22.9 %) of eligible children received the second DPT/OPV booster given at 5 years of age and only four (9.5 %) of eligible children in the study were completely vaccinated with the Tdap/HPV vaccines by 10–12 years of age (Table 3B).

None of the teenagers in the study had received complete immunization at the time of the study.

Parental unawareness/lack of information about the need to immunize their children was the most common reasons for partial/nonimmunization of the children (38.3%) (Table 4). Parents did not give much importance to immunization (0.8%) and appeared unaware of the healthcare facilities available to them (0.5%). Other prominent reasons included financial constraints (19%),

Table 3B: Distribution of study subjects according to the partial/noncoverage of immunization (part B)

	Age						
Immunization	*12 months*	*15 months*	*16–18 months*	*18 months*	*2 years*	*4–6 years*	*10–12 years*
Hepatitis A1	0						
MMR		149 (98.6)				103 (95.4)	
Varicella		150 (99.3)				105 (97.2)	
DTwP			21 (14.1)			50 (46.3)	
Hib			15 (10.1)				
PCV			135 (91.2)				
Hepatitis A2				0			
Typhoid					0		
OPV						50 (46.3)	
Tdap							36 (94.7)
HPV							12 (31.5)
Sum total of partial immunized	0 (0)	138 (54.3)	137 (57.3)	0	0	59 (42.1)	18 (42.8)
Sum total of partial and nonimmunized	166 (60.8)	151 (59.4)	148 (61.9)	145 (65)	130 (61.6)	108 (77.1)	38 (90.5)

Table 4: Distribution of study subjects according to the reasons for partial/nonimmunization (*N* = 378)

Reason	*Yes*	*NA*
Unaware of the need of immunization/lack of information	145 (38.3%)	233
Financial issue	71 (18.7%)	307
Child being ill	68 (17.9%)	310
Postponing immunization until another time	35 (9.2%)	343
No faith in immunization	6 (1.5)	372
Mother being too busy	5 (1.3)	373
Accessibility problem	5 (1.3)	373
Being single parent	5 (1.3)	373
Others (parents forgot about vaccination)	5 (1.3)	373
Vaccination not deemed necessary	3 (0.8)	375
Place of immunization being too far away	2 (0.5)	376
Knowledge of health services	2 (0.5)	376
Fear of immunization reaction	1 (0.2)	377
Migration	1 (0.2)	377
Unaware of the need to return for second or third dose	0	378
Vaccine not considered effective	0	378
VPDs not considered severe	0	378
Fear of exposing child to needles	0	378
Media exposure	0	378

childhood illness (17.9%), and postponing vaccination to a later time for no specific reason (9.2%). Other causes included a lack of faith in the positive effects of immunization (1.5%), parents being too busy to bring the child for vaccination (1.3%), healthcare accessibility issues (1.3), far distance of healthcare facility from the home (1.5%), single-parent family (1.3%), fear of immunization reaction (0.2%), parental forgetfulness (1.3%), and migration from place of origin (0.2%).

Discussion

Our study showed that immunization rates are highest at birth and subsequently the rates decline as the child grows older. We observed that by 1 year of age, 56.7% of eligible children were completely immunized, followed by 23% of eligible children aged 4–6 years. Only 9.5% of children in the age-group 10–12 years were completely immunized. None of the teenagers in the study were completely immunized. Similar results were found in a study conducted by Wood et al.,[10] where immunization coverage of children decreased as the child age increased from 3 months to 24 months.

Reasons for this could include (a) vaccines being given at less frequent intervals in older age groups compared to the more frequent intervals during the first 2 years of life, (b) escalating costs associated with vaccination, (c) parents not knowing about the vaccines available for older children, (d) children and parents are too busy or distracted by other pursuits and therefore don't remember about taking vaccination, (e) the older child is more assertive and does not wish to take the vaccines, (f) parents feel child is healthy and it is not important/not required for the healthy child to take vaccines.

We did not find any significant association between gender and immunization coverage. A study conducted by Khismatrao et al. (Pune) found no statistically significant difference in primary immunization coverage between different genders.[11] Conversely, Borooah et al.[12] studying gender bias and immunization status of children in India found that boys were five percentage points more fully vaccinated than girls. We feel that the lack of association between gender and immunization in our study could be because the children came mainly from the city, where more equal opportunities exist for boys and girls. Also, 80% of the families were of the upper and middle class, with better educated and informed parents.

We found that children coming from rural/more distant areas were significantly less likely to be completely immunized compared to those coming from the urban areas. Reasons for this could include financial constraints, lack of availability/accessibility to healthcare services, issues related to travel to and from the urban healthcare center from the rural area, and lack of knowledge about vaccination.

A study conducted by Adenika et al. in Nigeria, which found that 71% of urban population were completely immunized and 57% of rural population had complete immunization,[13] supported our study findings. But Nair[14] conducted a study in Kerala on immunization coverage in relation to six VPDs in urban, semiurban, and rural areas in Kerala, and found that the percentage of fully immunized children was similar in all areas. This difference can be explained by the fact that Kerala has the best healthcare facilities in our country and the local community there has better access to these facilities compared to people in other Indian states.

We assessed the ethnicity of our study subjects using two parameters: religion and language. We found no significant association between immunization coverage and these two factors, whereas a study by Shrivastwa et al.[15] showed inequalities in vaccination coverage among social and religious groups to be clearly present. Children from Muslim families had poorer vaccination outcomes and Christian children were found to be at elevated risk for undervaccination. Mathew[16] studied inequality in childhood immunization in India in 2012 and reported higher immunization coverage among Christians and Sikhs.

We used the modified Kuppuswamy Socioeconomic Scale to assess the education and socioeconomic status of the parents. Total 84% of the children in our study came from upper- and middle-class families and 15% of the children came from lower-class families. We found that children from the upper- and upper-middle-class (and therefore more educated parent) families were significantly more likely to be completely immunized for age compared to children from lower-class families. This underlines the fact that the better the socioeconomic status and education of the parents, particularly maternal education, the more positively it will influence the parents ability to access better health care and improve the immunization coverage of their children. Similarly, Jani et al. in 2016 showed that incomplete vaccination was prevalent more in children born to mothers with lower socioeconomic status.[17] Similar findings were seen in studies conducted by Dalal and Silveria[18] and Kar et al.[19] A study conducted by Merten et al.[20] found that women's low SE status manifest on every level as a barrier to accessing vaccination.

Most (58.2%) of the children in our study came from nuclear families and 39% came from joint families, but we did not find any significant association between the type of family and immunization coverage of the child. Conversely, a study by Nath et al.[21] found that belonging to a joint family was an independent predictor of non vaccination.

Only 3.6% of the children in our study came from single-parent families and 95.5% of the children had both parents at home. We did not find any significant association between immunization coverage and the marital status of the parents. This differed from a study conducted by Sackou et al.,[22] which concluded that marital status of the parents was an important determinant of immunization coverage. This could be due to the fact that financial constraints are possibly more common in single-parent families.

We had 140 children aged less than 18 months in our study. We looked for an association between immunization coverage of the child and antenatal care of the mothers during pregnancy. We found that all our 140 mothers had received adequate, regular antenatal care and counseling during pregnancy. Immunization coverage was complete in only 54.3% of their children and incomplete in 45.7% of the children, but this was not statistically significant. Comprehensive antenatal counseling, along with postnatal counseling regarding child vaccination could have improved the immunization rates of the children. Yenit et al.[23] conducted a study in children aged 12–23 months and found that children who were born to mothers who had no antenatal care during pregnancy were 2.76 times more likely to default on completion of child vaccination compared to infants who were born to mothers who had regular antenatal care during pregnancy.

Almost 84% of our mothers were aged between 20 and 35 years and 14% of our mothers were aged greater than 35 years. When we studied the effect of maternal age on immunization coverage, we found that advanced maternal age >35 years and young maternal age less than 20 years were associated with higher rates of children with incomplete immunization when compared to mothers in the age group 20–35 years ($p = 0.002$). Fatiregun et al.[24] found significant association between young caregivers less than 30 years of age with complete vaccination.

We examined the effect of maternal parity on the child's immunization coverage. Fifty-four percent of the mothers in our study were primiparous, and 46% of mothers had had more than one viable birth. We found a significant association between rising maternal parity index and decreasing immunization rates in the child. There was a 50% decline in child immunization coverage from 44.6 to 20.6% as maternal parity increased from para 1 to para 2 status, and coverage further declined by 7% as maternal parity increased. Awasthi et al. studied maternal determinants of the immunization status of children aged 12–23 months in the urban slums of Varanasi and also found similar results.[25] This could reflect the increased financial burden faced by the family as the size of the family increased.

Similarly, when we compared immunization coverage rates with the number of living children at home, we found that as the number of living children increased, the rates of complete immunization declined. Similar results were found in a study conducted by Roodpeyma et al.[26] and likely reflect the increased financial burden faced by a family with more children at home.

Ninety-nine percent of the mothers in our study delivered in a medical care center/hospital. But this did not translate into increased rates of complete immunization for their offspring (32.6%). In a cross-sectional study by Khurana et al.[27] in 2017, it was found that out of the incompletely immunized children, 30.2% were hospital delivered whereas 69.8% were delivered at home. Similar findings were seen in a study by Chhabra et al.[28] The lower rates of immunization may reflect the need to aggressively educate the mothers in the antenatal and postnatal periods about infant and child vaccination and its importance, as well as make vaccines available at the community level to improve immunization cover.

In our study, 271 (71.6%) of children belonged to birth order 1, and 104 (28%) of children were birth order 2 or higher. We found a 5% decrease in complete immunization rates as the birth order increased, but this was not statistically significant. A similar study done by Negussie in 2016 found that incomplete vaccination in children was significantly associated with children being born second, third, fourth, fifth, or later in the family as compared to being born first.[29] The reasons for this may be due to increased financial stress as the family size increases, parents being preoccupied with the care of the newer/younger children, or parents being unaware of the continuing vaccination needs of the previous child.

Forty-nine percent of our study children received vaccination from a government health facility and an equal number of children got the vaccination from a private/nongovernmental source. Total 2.6% of children got vaccinations from both sources.

The vaccination card was available for confirming immunization in only 55% of our study children. In 45% of children, the card was unavailable, suggesting parents did not recognize the importance of the immunization card. In these parents, immunization recall was used to assess the immunization status of the child.

A marked decrease in immunization rates (Table 2) from birth to 6 weeks of age was likely due to children returning to their maternal homes and receiving their vaccination from sources outside of the birth hospital. Also, all government care centers may not give pneumococcal (PCV) and rotavirus vaccines. This, coupled with parental financial constraints, explains the significant decrease in immunization rates seen in this population.

Between 6 and 14 weeks, the immunization rates remained steady (98–99% for the NIP and 43–44% for the IAP 2016). At 6 months of age, 54% children did not return for OPV vaccination as the NIP does not recommend any OPV vaccination at this age. At 9 months of age, differences in vaccination rates occurred as government centers provide MR-OPV vaccines rather than the MMR-OPV recommended by the IAP 2016 schedule. The overall immunization coverage at 9 months was 97.8% for the MR vaccine according to NIP and 36.6% as per the IAP 2016 schedule. This same reason also accounted for similar difference in vaccination rates at 15 months of age in our population. Only 38–39% of eligible children took optional vaccines such as typhoid and hepatitis A vaccines by 12–15 months and 2 years of age. At 18 months, immunization coverage as per the NIP was 95% and immunization coverage as per the IAP 2016 recommendations was 38%. By 4–6 years, 65% of eligible children received the vaccination as per the NIP and 23% of eligible children received their vaccination as per the IAP 2016 schedule recommendations. At 10–12 years, vaccination rates were down to 9.5%, with 47.6% of children not taking the Tdap/HPV vaccines.

In our study, the most common reason for incomplete immunization was unawareness of the need for ongoing vaccination. This was found in other studies as well. Mugada et al.[30] in AP, India, in 2017 found that poor awareness of mothers regarding age-related vaccines and unawareness of the need for immunization was one of the most common causes for incomplete immunization, despite the fact that most of the parents were literate and employed. Francis et al.[31] studied factors associated with routine immunization and also found that the reason for nonvaccination was a gap in awareness of vaccination. Other common reasons for incomplete vaccination in our study included financial constraints, childhood illness interfering with child's ability to get vaccinated, and postponing vaccination to a later date for no particular reason. This tells us that education of parents and children about vaccinations is the need of the hour if we are to properly protect our communities from VPDs. This education must be aggressive, timely, comprehensive, and target the mother/parents in the antenatal period, in the immediate postnatal period, at every vaccination/child health visit, as well as target teachers and schoolchildren alike. Various media like television, cable TV, phone messages, as well as posters can help bring awareness about immunization to the people. Our government representatives must also be educated about the need to expand the immunization program so as to cover health issues such as pneumococcal, rotavirus, typhoid, mumps, hepatitis A, and chicken pox vaccination to promote better health for our communities.

Strengths

We were able to assess the immunization status and identify factors impacting immunization in children attending our hospital. Our study conveys a reasonable picture of the varying rates of immunization in an urban population of children. Our study has also identified the periods in a child's life when health workers can update/educate parents about their child's immunization opportunities so that complete immunization coverage rates can be achieved. In this way, our study is useful to health workers.

Limitations

The immunization card of 45% of children in the study could not be checked, due to unavailability of the card. The immunization status of these children was assessed based on parental recall, which can often be erroneous and biased. Few parents did not answer all questions in the questionnaire. Since our study consisted of children coming from mainly urban areas, demonstration of the true picture of immunization coverage rates in rural areas would require inclusion of a larger population of subjects from the rural areas.

Conclusion

We concluded that immunization rates are highest at birth and subsequently the immunization rates decline as the child grows older. Factors that significantly negatively impact a child's immunization coverage include older age of the child, origin from rural area, lower education and socioeconomic status of the parents, maternal ages less than 20 years and greater than 35 years, rising parity index of the mother, and increased number of living children at home. Factors that positively influenced the immunization status included lower age of the child, maternal age between 20 years and 35 years, better education, and socioeconomic status of the parents, less maternal parity, and less number of living children.

The most common reasons for partial/nonvaccination included unawareness of the need for vaccination, financial constraints, child being ill, and postponing vaccination to another time for no apparent reason.

To increase parental knowledge about immunization, periods of time when the importance of immunization and the immunization opportunities available could be stressed, including during the antenatal period, the immediate postnatal period, every vaccination/child health visit or hospital admission, as well as targeting schoolchildren/teachers through school health programs would help keep the focus on immunization. Immunization is, and should be recognized as, a core component of the human right to health and is a personal and collective community responsibility.

Recommendations

The information regarding the importance of vaccination must be imparted to parents at regular intervals, as mentioned above. Mother should be sensitized at every child health visit about the child's next vaccination opportunity, where it is available and how she can access it. The need to retain and maintain the vaccination card carefully must be stressed. Immunization card should clearly show what vaccinations are available and the age at which the child should get these vaccines. Making the immunization card mandatory for entry to school may not be democratic, but the importance of the immunization card can be further underlined by perusal of the immunization card at school entry and at regular intervals thereafter. Parents have to be made aware that the immunization card is an important document, which must be preserved past the teenage years and must be produced at every child visit regardless of the status of the child. Immunization card should be expanded to

cover the different stages of child's life (infancy–teenage age) and development, and be made more relevant to the child issues. Setting up of a system for monitoring the incidence of VPDs and conducting appropriate epidemiological studies is necessary to make evidence-based decisions on incorporation of optional vaccines such as typhoid vaccines in the National Immunization schedule. As majority were unaware of the need for ongoing immunization despite belonging to an urban area, efforts should be made in educating them, through mass media to improve coverage rates of both NIP and IAP schedule vaccines, especially typhoid, hep A, varicella, PCV and rotavirus vaccines, and mumps, which are so far not been given to the general public as per the NIP. Suitable reminders for vaccination using available media like the mobile phone messages, TV advertisements, and billboard posters can help spread awareness about vaccination visits. Improvements in vaccination coverage may be obtained through fathers' and communities' involvement in vaccination initiatives. The transformative power of men's involvement through innovative programming can help to address power inequalities resulting from gender bias. When immunization of children becomes a family and community responsibility, more progress can be made. Pediatricians and other medical staff are required to communicate with clarity and appropriate information regarding the immunization schedule of the child and the importance of vaccination. Immunization status must be checked during the sick child visit/hospital admissions. Recommendation for immunization should be made prior to hospital discharge or at first postdischarge visit. No child should be denied vaccination and licensed newer vaccines should be made affordable and available to needy children in an equitable manner. The government must take up manufacturing of optional vaccines through public–private partnerships to improve coverage and reduce endemic diseases.

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